Crash Course in the EPA Superfund Risk Assessment Process

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Topics to be Covered

Overview of the Risk Assessment

Data Collection and Evaluation

The Toxicity Assessment

The Exposure Assessment

Risk Characterization

What is a Risk Assessment?

A Risk Assessment is NOT…

- A study of health conditions people or animals may already have.
- A re-creation of ways people, flora or fauna might have been exposed to contaminants in the past.
- A study that will tell whether any existing health problems were caused by past contact with chemicals.

What is a Risk Assessment?

A Risk Assessment IS…

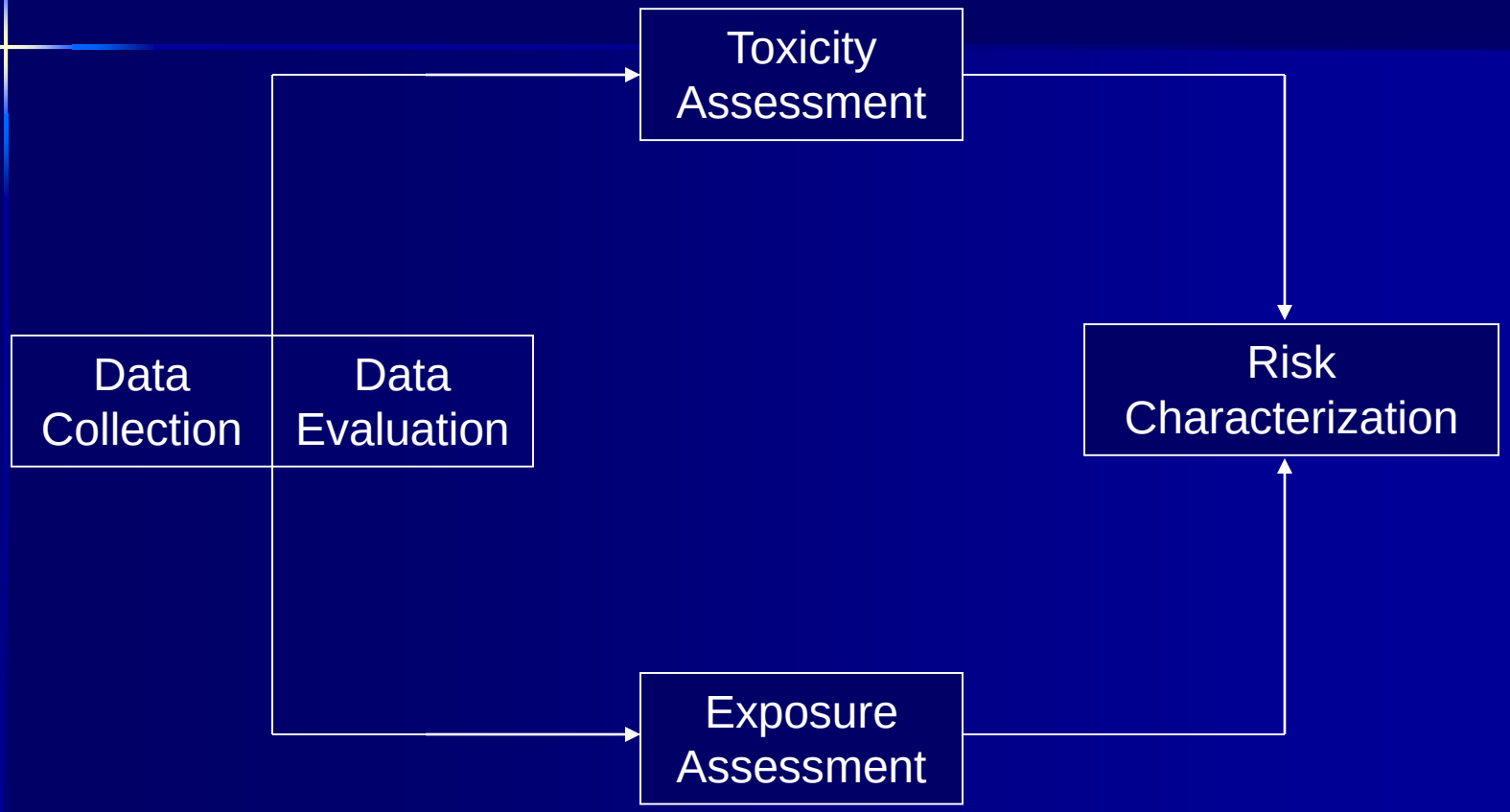
- A tool to assist EPA in protecting human health and the environment.
- A comprehensive study of the various ways people, flora or fauna might be in contact with chemicals.
- Calculation of how likely it is that health effects **might** occur in the future because of chemicals in the neighborhood.

What is Risk?

Risk = Toxicity x Exposure

- Toxicity = Chemical's ability to cause adverse health effects
- Exposure = Concentration + Route + Time

Risk Assessment Paradigm



Risk Assessment Paradigm

1. Data Collection and Evaluation

   What contaminants exist and are of potential concern?

2. Toxicity Assessment

   At what level of exposure are adverse effects likely to occur?

3. Exposure Assessment

   How might a receptor be exposed on or off site?

4. Risk Characterization

   What are the risks and uncertainties at the site?

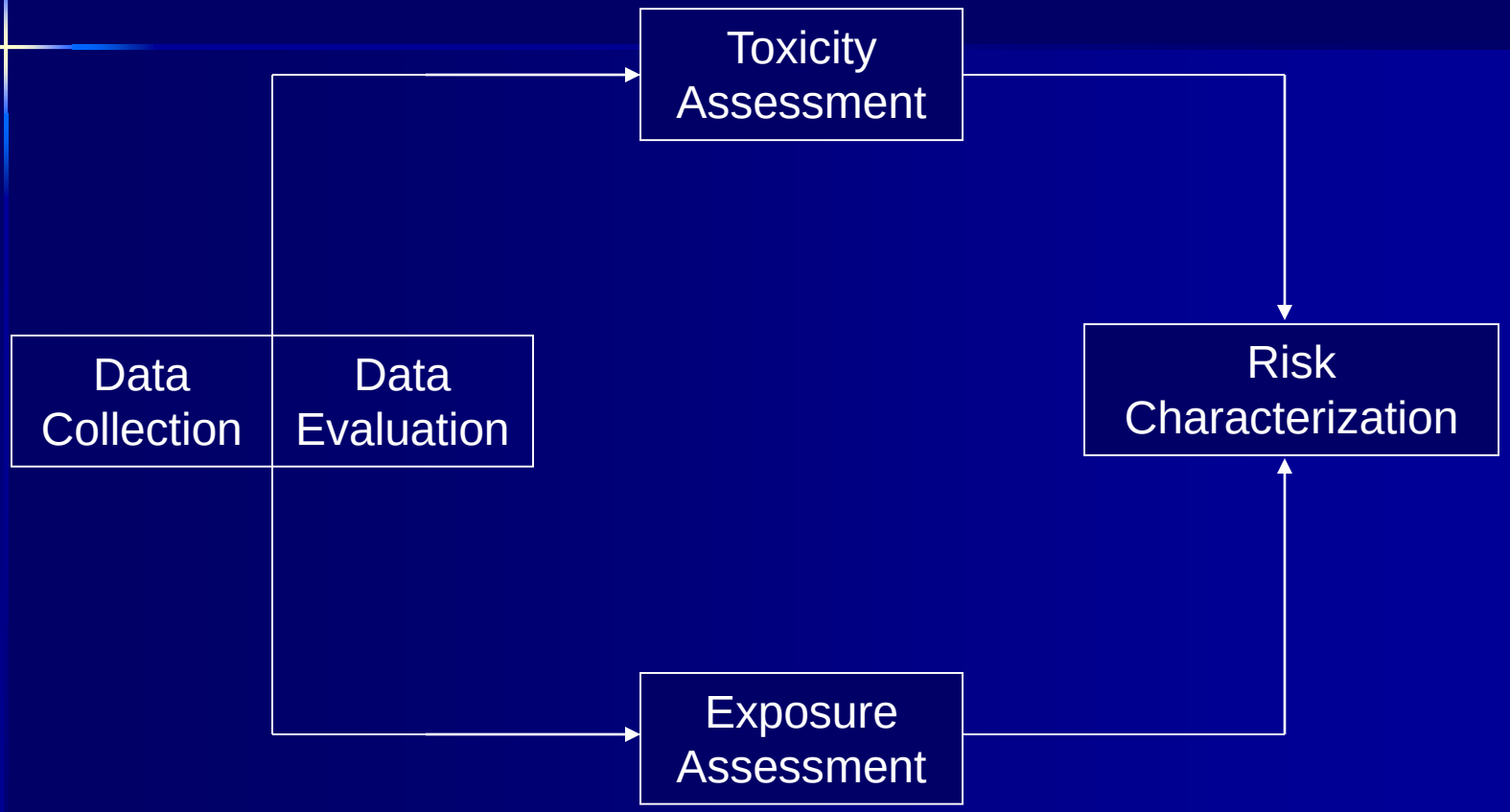
Risk Assessment Guidance for Superfund (RAGS)

- RAGS part A – Human Health Evaluation Manual (1989)
- RAGS part B – Development of Risk-based Preliminary Remediation Goals (1991)
- RAGS part C – Risk Evaluation of Remedial Alternatives (1991)
- RAGS part D – Standardized Planning, Reporting and Review of Superfund Risk Assessments (1998)
- RAGS part E - Supplemental Guidance for Dermal Risk Assessment (2004)
- RAGS part F - Supplemental Guidance for Inhalation Risk Assessment (2009)

Additional Resources

- Ecological Screening Guidances
- Soil Screening Level Guidance
- Exposure Factors Handbook
- Regional Screening Level Tables (RSL)
- Vapor Intrusion Screening Level (VISL) calculator
- State Applicable or Relevant and Appropriate Requirements (ARARS)
- Etc…

Risk Assessment Paradigm



Types of data required

- Historical information
- Contaminant identities
- Contaminant concentrations
- Characteristics of contaminant sources
- Exposure point sources and media of interest
- Characteristics of the environmental setting

Review Historical Information

- Prevent duplication of effort
- Identify data gaps
- Identify changes of analyses
- Determine basic site characteristics

Sampling Plan Questions

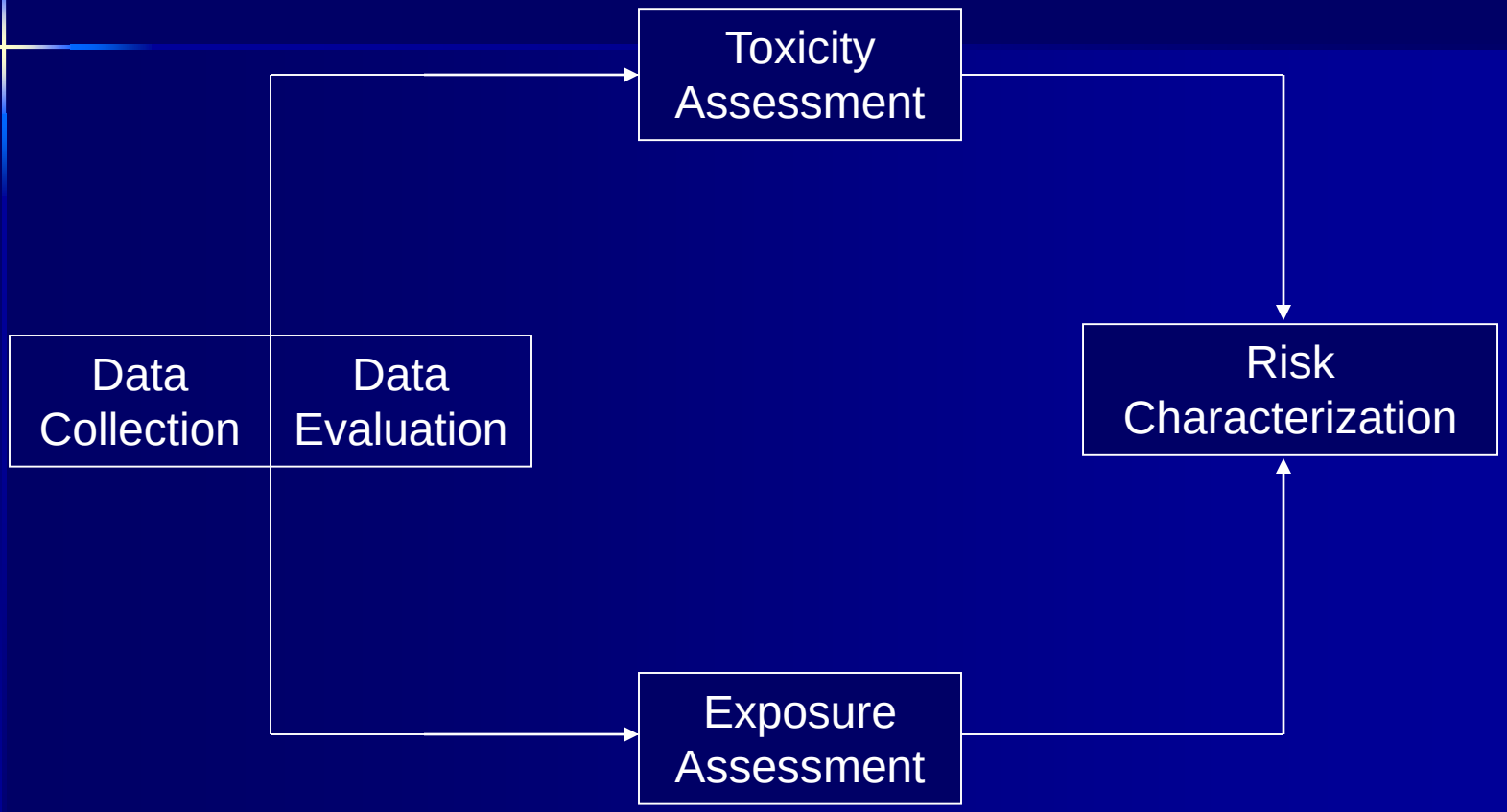
- What contaminants are present and where?
- Are all exposure areas and pathways identified and fully characterized?
- Will background be an issue?

Background Samples

Background – substances or locations not influenced by releases from the site and usually described as naturally occurring.

Background sampling is conducted to distinguish site related contamination from naturally occurring or other anthropogenic sources of contamination.

Risk Assessment Paradigm



Toxicity Assessment

- Only part of the Risk Assessment that is not site specific.
- It is chemical specific.
- The real work takes place in the research lab.

Toxicity Assessment

- Major literature search to determine if any data has been published that shows if…
  - There is potential for particular contaminants to cause adverse effects in exposed individuals (Hazard Identification).
  - And to provide, if possible, an estimate of the dose which may lead to an increased likelihood of adverse health effects (Dose Response).

Toxicity Assessment

Sources of Toxicity Information

- Human Epidemiology Studies
  - Most definitive source but limited on availability and usefulness.
- Animal Toxicity Studies
  - Long lasting assumption that effects in humans can be inferred.
- Supporting Data
  - Pharmacokinetics, mechanisms of action, structure/activity relationships, and *in vitro* studies.

Toxicity Assessment

- If the assessor is lucky, the toxicity assessments for the chemicals of concern will have already been done and peer reviewed.
- Finalized data of these assessments can be found in
  - Integrated Risk Information System (IRIS)
  - Provisional Peer Reviewed Toxicity Values (PPRTVs)
  - Health Effects Assessment Summary Tables (HEAST)
  - other sources (i.e. ATSDR, Cal EPA)

Key: I = IRIS; P = PPRTV; A = ATSDR; C = Cal EPA; X = PPRTV Appendix; H = HEAST; J = New Jersey; E = Environmental Criteria and Assessment Office; S = see user guide Section 5; L = see user guide on lead; M = mutagen; V = volatile; F = See FAQ #29; c = cancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; n = noncancer; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide); SSL values are based on DAF=1

Toxicity and Chemical-specific information														Contaminant		Screening Levels												Protection of Ground Water SSLs	
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD_o (mg/kg-day)	key	RfC_i (mg/m^3)	key	volatile	muta-gen	GIABS	ABS	C_{sat} (mg/kg)	Analyte	CAS No.	Resident Soil (mg/kg)	key	Industrial Soil (mg/kg)	key	Resident Air (ug/m^3)	key	Industrial Air (ug/m^3)	key	Tapwater (ug/L)	key	MCL (ug/L)	Risk-based SSL (mg/kg)	MCL-based SSL (mg/kg)
1.8E-02	C	5.1E-06	C	1.5E-01	I					1	0.1		ALAR	1596-84-5	2.7E+01	c	9.6E+01	c	4.8E-01	c	2.4E+00	c	3.7E+00	c		8.2E-04	
8.7E-03	I			4.0E-03	I					1	0.1		Acephate	30560-19-1	5.6E+01	c**	2.0E+02	c*					7.7E+00	c*		1.7E-03	
		2.2E-06	I			9.0E-03	I	V		1		1.1E+05	Acetaldehyde	75-07-0	1.0E+01	c**	5.2E+01	c**	1.1E+00	c**	5.6E+00	c**	2.2E+00	c**		4.5E-04	
				2.0E-02	I					1	0.1		Acetochlor	34256-82-1	1.2E+03	n	1.2E+04	n					7.3E+02	n		5.8E-01	
				9.0E-01	I	3.1E+01	A	V		1		1.1E+05	Acetone	67-64-1	6.1E+04	n	6.3E+05	nms	3.2E+04	n	1.4E+05	n	2.2E+04	n		4.5E+00	
				3.0E-03	P	6.0E-02	P	V		1		1.1E+05	Acetone Cyanohydrin	75-86-5	2.0E+02	n	2.1E+03	n	6.3E+01	n	2.6E+02	n	5.8E+01	n		1.2E-02	
						6.0E-02	I	V		1		1.3E+05	Acetonitrile	75-05-8	8.7E+02	n	3.7E+03	n	6.3E+01	n	2.6E+02	n	1.3E+02	n		2.6E-02	
				1.0E-01	I			V		1		2.5E+03	Acetophenone	98-86-2	7.8E+03	ns	1.0E+05	nms					3.7E+03	n		1.1E+00	
3.8E+00	C	1.3E-03	C							1	0.1		Acetylaminofluorene, 2-	53-96-3	1.3E-01	c	4.5E-01	c	1.9E-03	c	9.4E-03	c	1.8E-02	c		8.2E-05	
				5.0E-04	I	2.0E-05	I	V		1		2.3E+04	Acrolein	107-02-8	1.5E-01	n	6.5E-01	n	2.1E-02	n	8.8E-02	n	4.2E-02	n		8.4E-06	
5.0E-01	I	1.0E-04	I	2.0E-03	I	6.0E-03	I		M	1	0.1		Acrylamide	79-06-1	2.3E-01	c	3.4E+00	c	9.6E-03	c	1.2E-01	c	4.3E-02	c		9.1E-06	
				5.0E-01	I	1.0E-03	I			1	0.1		Acrylic Acid	79-10-7	3.0E+04	n	2.9E+05	nm	1.0E+00	n	4.4E+00	n	1.8E+04	n		3.7E+00	
5.4E-01	I	6.8E-05	I	4.0E-02	A	2.0E-03	I	V		1		1.1E+04	Acrylonitrile	107-13-1	2.4E-01	c*	1.2E+00	c*	3.6E-02	c*	1.8E-01	c*	4.5E-02	c*		9.9E-06	
						6.0E-03	P			1	0.1		Adiponitrile	111-69-3	8.5E+06	nm	3.6E+07	nm	6.3E+00	n	2.6E+01	n					
5.6E-02	C			1.0E-02	I					1	0.1		Alachlor	15972-60-8	8.7E+00	c*	3.1E+01	c					1.2E+00	c	2.0E+00	9.9E-04	1.6E-03
				1.0E-03	I					1	0.1		Aldicarb	116-06-3	6.1E+01	n	6.2E+02	n					3.7E+01	n		9.1E-03	
				1.0E-03	I					1	0.1		Aldicarb Sulfone	1646-88-4	6.1E+01	n	6.2E+02	n					3.7E+01	n		8.0E-03	
1.7E+01	I	4.9E-03	I	3.0E-05	I					1	0.1		Aldrin	309-00-2	2.9E-02	c*	1.0E-01	c	5.0E-04	c	2.5E-03	c	4.0E-03	c		6.5E-04	
				2.5E-01	I					1	0.1		Allyl	74223-64-6	1.5E+04	n	1.5E+05	nm					9.1E+03	n		3.5E+00	
				5.0E-03	I	1.0E-04	X			1	0.1		Allyl Alcohol	107-18-6	3.0E+02	n	3.1E+03	n	1.0E-01	n	4.4E-01	n	1.8E+02	n		3.7E-02	
2.1E-02	C	6.0E-06	C			1.0E-03	I	V		1		1.4E+03	Allyl Chloride	107-05-1	6.8E-01	c**	3.4E+00	c**	4.1E-01	c**	2.0E+00	c**	6.5E-01	c**		2.1E-04	
				1.0E+00	P	5.0E-03	P			1			Aluminum	7429-90-5	7.7E+04	n	9.9E+05	nm	5.2E+00	n	2.2E+01	n	3.7E+04	n		5.5E+04	
				4.0E-04	I					1			Aluminum Phosphide	20859-73-8	3.1E+01	n	4.1E+02	n					1.5E+01	n			
				3.0E-04	I					1	0.1		Amdro	67485-29-4	1.8E+01	n	1.8E+02	n					1.1E+01	n		3.9E+03	
				9.0E-03	I					1	0.1		Ametryn	834-12-8	5.5E+02	n	5.5E+03	n					3.3E+02	n		3.5E-01	
2.1E+01	C	6.0E-03	C							1	0.1		Aminobiphenyl, 4-	92-67-1	2.3E-02	c	8.2E-02	c	4.1E-04	c	2.0E-03	c	3.2E-03	c		1.6E-05	
				8.0E-02	P					1	0.1		Aminophenol, m-	591-27-5	4.9E+03	n	4.9E+04	n					2.9E+03	n		1.1E+00	
				2.0E-02	P					1	0.1		Aminophenol, p-	123-30-8	1.2E+03	n	1.2E+04	n					7.3E+02	n		2.8E-01	
				2.5E-03	I					1	0.1		Amitraz	33089-61-1	1.5E+02	n	1.5E+03	n					9.1E+01	n		4.7E+01	
						1.0E-01	I			1			Ammonia	7664-41-7					1.0E+02	n	4.4E+02	n					
				7.0E-04	I					1			Ammonium Perchlorate	7790-98-9	5.5E+01	n	7.2E+02	n					2.6E+01	n			
				2.0E-01	I					1			Ammonium Sulfamate	7773-06-0	1.6E+04	n	2.0E+05	nm					7.3E+03	n			
5.7E-03	I	1.6E-06	C	7.0E-03	P	1.0E-03	I			1	0.1		Aniline	62-53-3	8.5E+01	c**	3.0E+02	c*	1.0E+00	n	4.4E+00	n	1.2E+01	c*		4.0E-03	
				4.0E-04	I					0.15			Antimony (metallic)	7440-36-0	3.1E+01	n	4.1E+02	n					1.5E+01	n	6.0E+00	6.6E-01	2.7E-01
				5.0E-04	H					0.15			Antimony Pentoxide	1314-60-9	3.9E+01	n	5.1E+02	n					1.8E+01	n			
				9.0E-04	H					0.15			Antimony Potassium Tartrate	11071-15-1	7.0E+01	n	9.2E+02	n					3.3E+01	n			
				4.0E-04	H					0.15			Antimony Tetroxide	1332-81-6	3.1E+01	n	4.1E+02	n					1.5E+01	n			
						2.0E-04	I			0.15			Antimony Trioxide	1309-64-4	2.8E+05	nm	1.2E+06	nm	2.1E-01	n	8.8E-01	n					
				1.3E-02	I					1	0.1		Apollo	74115-24-5	7.9E+02	n	8.0E+03	n					4.7E+02	n		2.9E+01	
2.5E-02	I	7.1E-06	I	5.0E-02	H					1	0.1		Aramite	140-57-8	1.9E+01	c	6.9E+01	c	3.4E-01	c	1.7E+00	c	2.7E+00	c		3.0E-02	
1.5E+00	I	4.3E-03	I	3.0E-04	I	1.5E-05	C			1	0.03		Arsenic, Inorganic	7440-38-2	3.9E-01	c*	1.6E+00	c	5.7E-04	c*	2.9E-03	c*	4.5E-02	c	1.0E+01	1.3E-03	2.9E-01
				3.5E-06	C	5.0E-05	I			1			Arsine	7784-42-1	2.7E-01	n	3.6E+00	n	5.2E-02	n	2.2E-01	n	1.3E-01	n			
				9.0E-03	I					1	0.1		Assure	76578-14-8	5.5E+02	n	5.5E+03	n					3.3E+02	n		5.1E+00	
				5.0E-02	I					1	0.1		Asulam	3337-71-1	3.1E+03	n	3.1E+04	n					1.8E+03	n		4.7E-01	
2.3E-01	C			3.5E-02	I					1	0.1		Atrazine	1912-24-9	2.1E+00	c	7.5E+00	c					2.9E-01	c	3.0E+00	1.9E-04	1.9E-03
8.8E-01	C	2.5E-04	C							1	0.1		Auramine	492-80-8	5.5E-01	c	2.0E+00	c	9.7E-03	c	4.9E-02	c	7.6E-02	c		7.0E-04	
				4.0E-04	I					1	0.1		Avermectin B1	65195-55-3	2.4E+01	n	2.5E+02	n					1.5E+01	n		2.6E+01	
1.1E-01	I	3.1E-05	I					V		1			Azobenzene	103-33-3	5.1E+00	c	2.3E+01	c	7.8E-02	c	4.0E-01	c	1.2E-01	c		9.6E-04	
				2.0E-01	I	5.0E-04	H			0.07			Barium	7440-39-3	1.5E+04	n	1.9E+05	nm	5.2E-01	n	2.2E+00	n	7.3E+03	n	2.0E+03	3.0E+02	8.2E+01
				4.0E-03	I					1	0.1		Baygon	114-26-1	2.4E+02	n	2.5E+03	n					1.5E+02	n		4.7E-02	
				3.0E-02	I					1	0.1		Bayleton	43121-43-3	1.8E+03	n	1.8E+04	n					1.1E+03	n		8.7E-01	
				2.5E-02	I					1	0.1		Baythroid	68359-37-5	1.5E+03	n	1.5E+04	n					9.1E+02	n		2.4E+02	
				3.0E-01	I					1	0.1		Benefin	1861-40-1	1.8E+04	n	1.8E+05	nm					1.1E+04	n		3.6E+02	
				5.0E-02	I					1	0.1		Benomyl	17804-35-2	3.1E+03	n	3.1E+04	n					1.8E+03	n		1.6E+00	
				3.0E-02	I					1	0.1		Bentazon	25057-89-0	1.8E+03	n	1.8E+04	n					1.1E+03	n		2.4E-01	
				1.0E-01	I			V		1		1.2E+03	Benzaldehyde	100-52-7	7.8E+03	ns	1.0E+05	nms					3.7E+03	n		8.1E-01	
5.5E-02	I	7.8E-06	I	4.0E-03	I	3.0E-02	I	V		1		1.8E+03	Benzene	71-43-2	1.1E+00	c*	5.4E+00	c*	3.1E-01	c	1.6E+00	c*	4.1E-01	c	5.0E+00	2.1E-04	2.6E-03
				1.0E-05	H			V		1		1.3E+03	Benzenethiol	108-98-5	7.8E-01	n	1.0E+01	n					3.7E-01	n		2.4E-04	
2.3E+02	I	6.7E-02	I	3.0E-03	I				M	1	0.1		Benzidine	92-87-5	5.0E-04	c	7.5E-03	c	1.4E-05	c	1.8E-04	c	9.4E-05	c		2.4E-07	
				4.0E+00	I					1	0.1		Benzoic Acid	65-85-0	2.4E+05	nm	2.5E+06	nm					1.5E+05	n		3.4E+01	
1.3E+01	I							V		1		3.2E+02	Benzotrichloride	98-07-7	4.9E-02	c	2.2E-01	c					5.2E-03	c		1.1E-05	
				1.0E-01	P					1	0.1		Benzyl Alcohol	100-51-6	6.1E+03	n	6.2E+04	n					3.7E+03	n		8.9E-01	
1.7E-01	I	4.9E-05	C	2.0E-03	P	1.0E-03	P	V		1		1.5E+03	Benzyl Chloride	100-44-7	1.0E+00	c*	4.9E+00	c*	5.0E-02	c*	2.5E-01	c*	7.9E-02	c*		8.7E-05	
		2.4E-03	I	2.0E-03	I	2.0E-05	I			0.007			Beryllium and compounds	7440-41-7	1.6E+02	n	2.0E+03	n	1.0E-03	c*	5.1E-03	c*	7.3E+01	n	4.0E+00	5.8E+01	3.2E+00
				1.0E-04	I					1	0.1		Bidrin	141-66-2	6.1E+00	n	6.2E+01	n					3.7E+00	n		8.5E-04	

Toxicity Assessment

Non-Cancer vs. Cancer

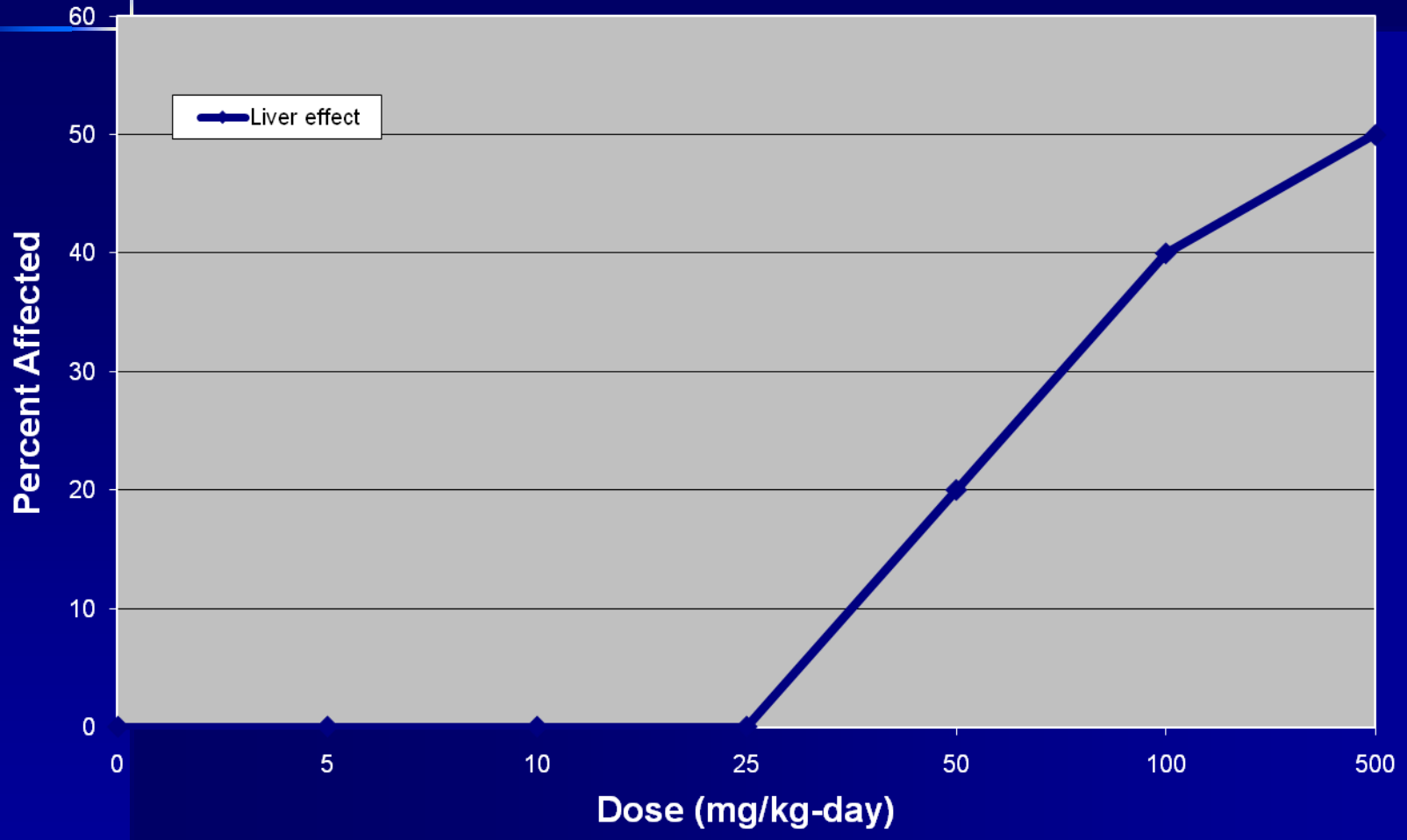
Non-Cancer

- Threshold
- Reference Dose
  - An estimate of daily exposure level for the human population, that is likely to be without an appreciable risk of deleterious effects during a lifetime.

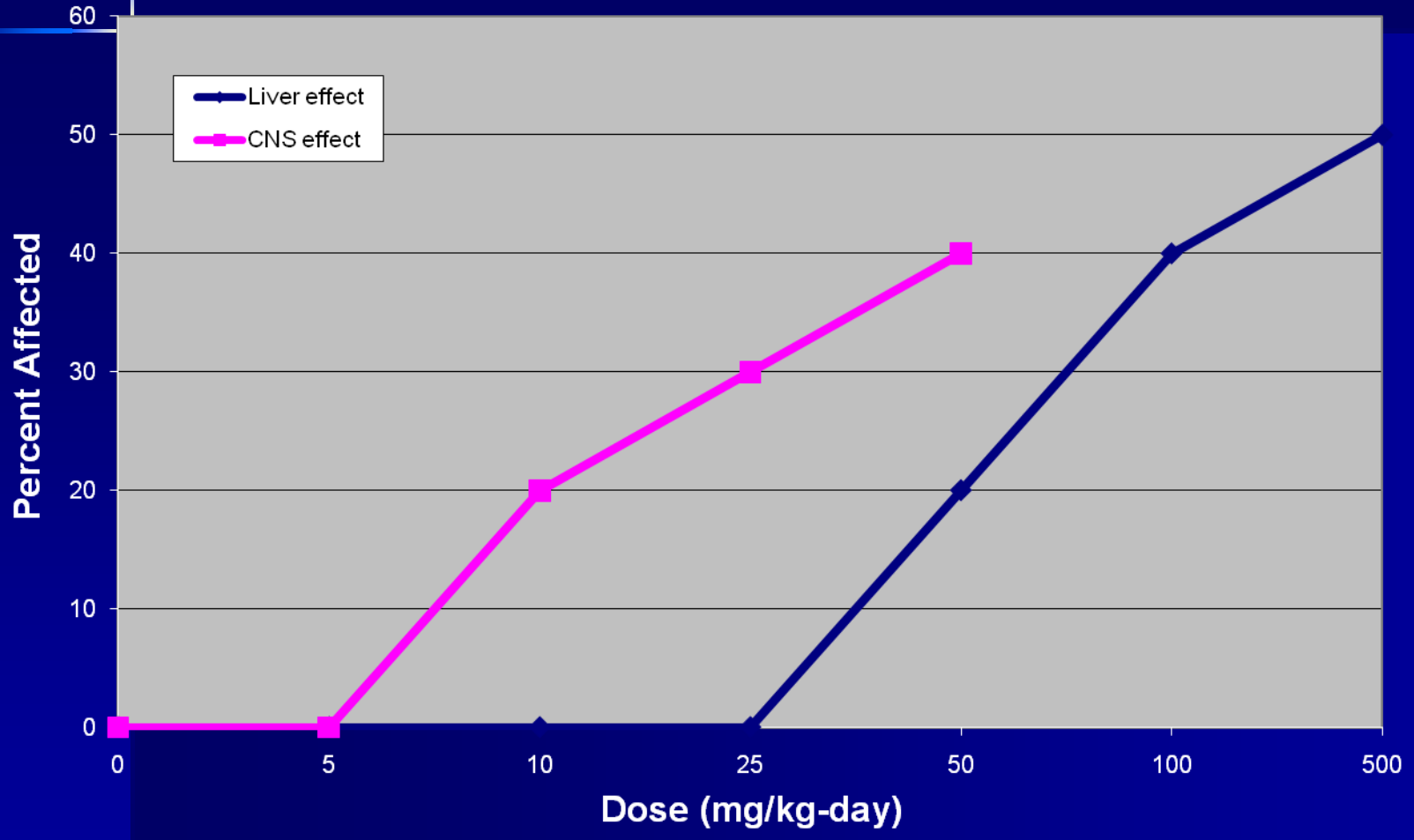
Cancer

- Non-Threshold
- Slope Factor
  - An upper-bound estimate of a chemical's probability to cause cancer over a 70 year lifetime.

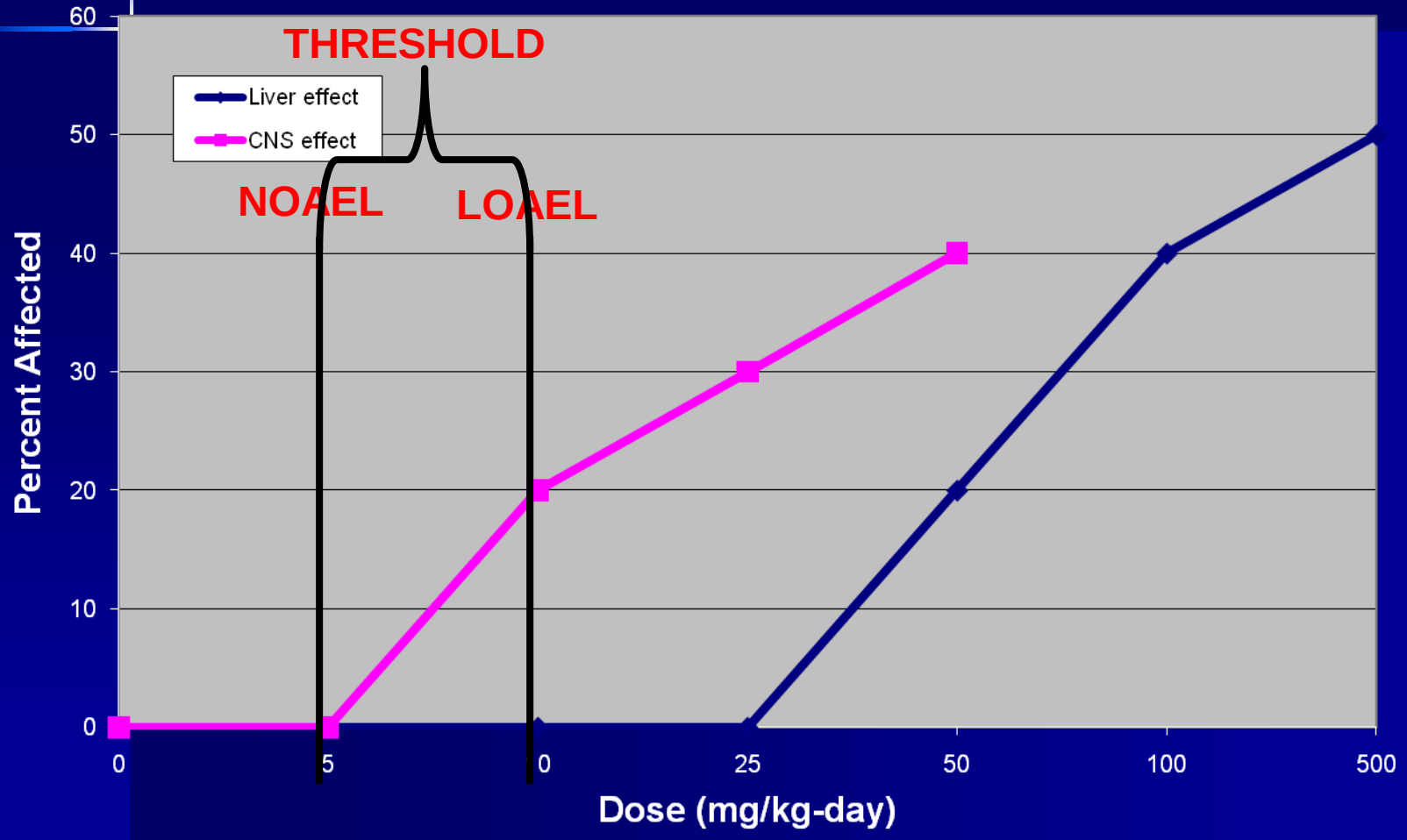
Dose Response Curves



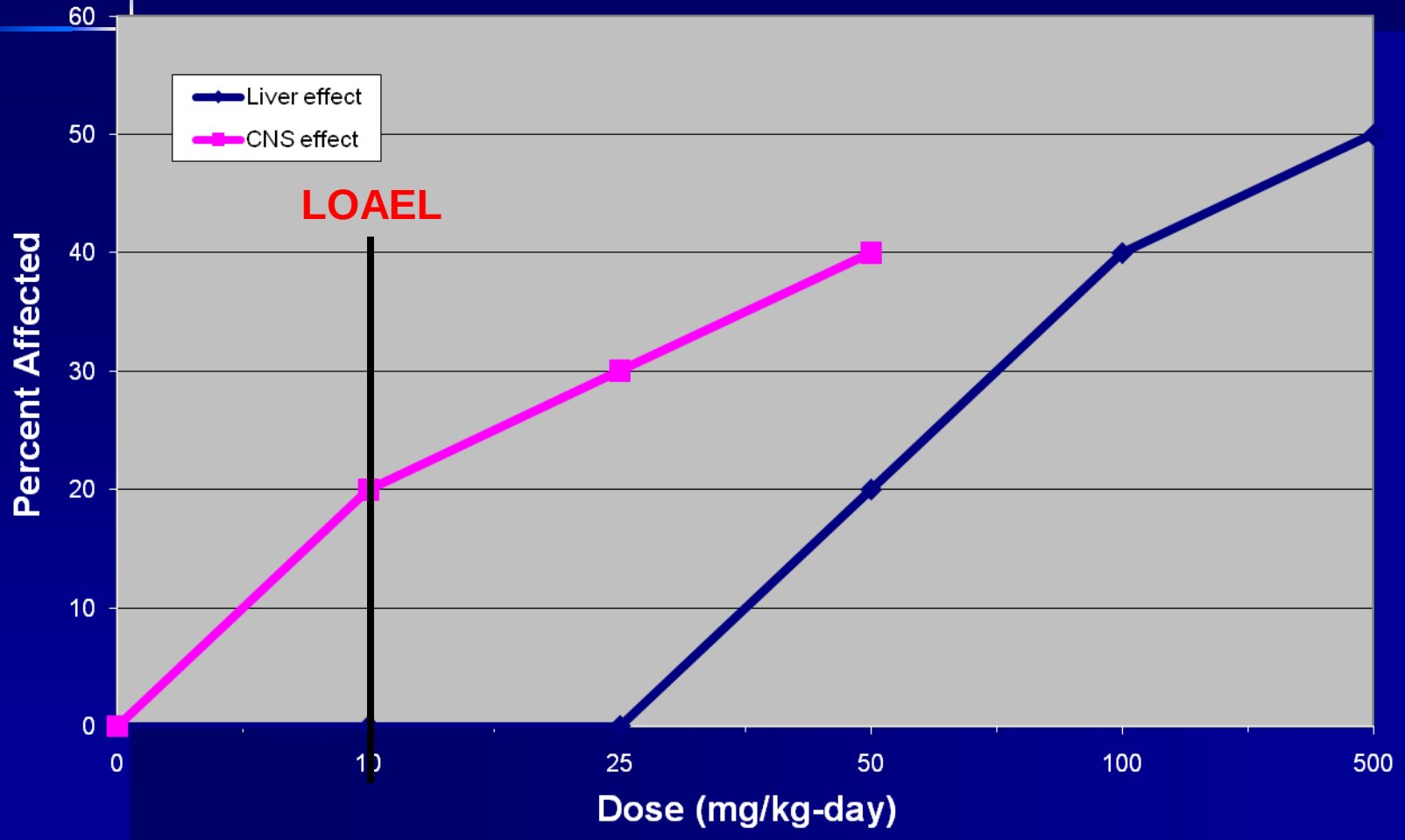
Dose Response Curves



Dose Response Curves



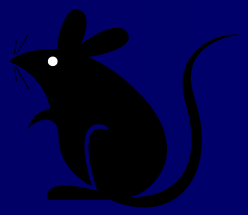
Dose Response Curves



Saftey Factors

1000 µg/kg-day

LOAEL / 10 NOAEL 100 µg/kg-day



/ 10

10 µg/kg-day

/10

1 µg/kg-day

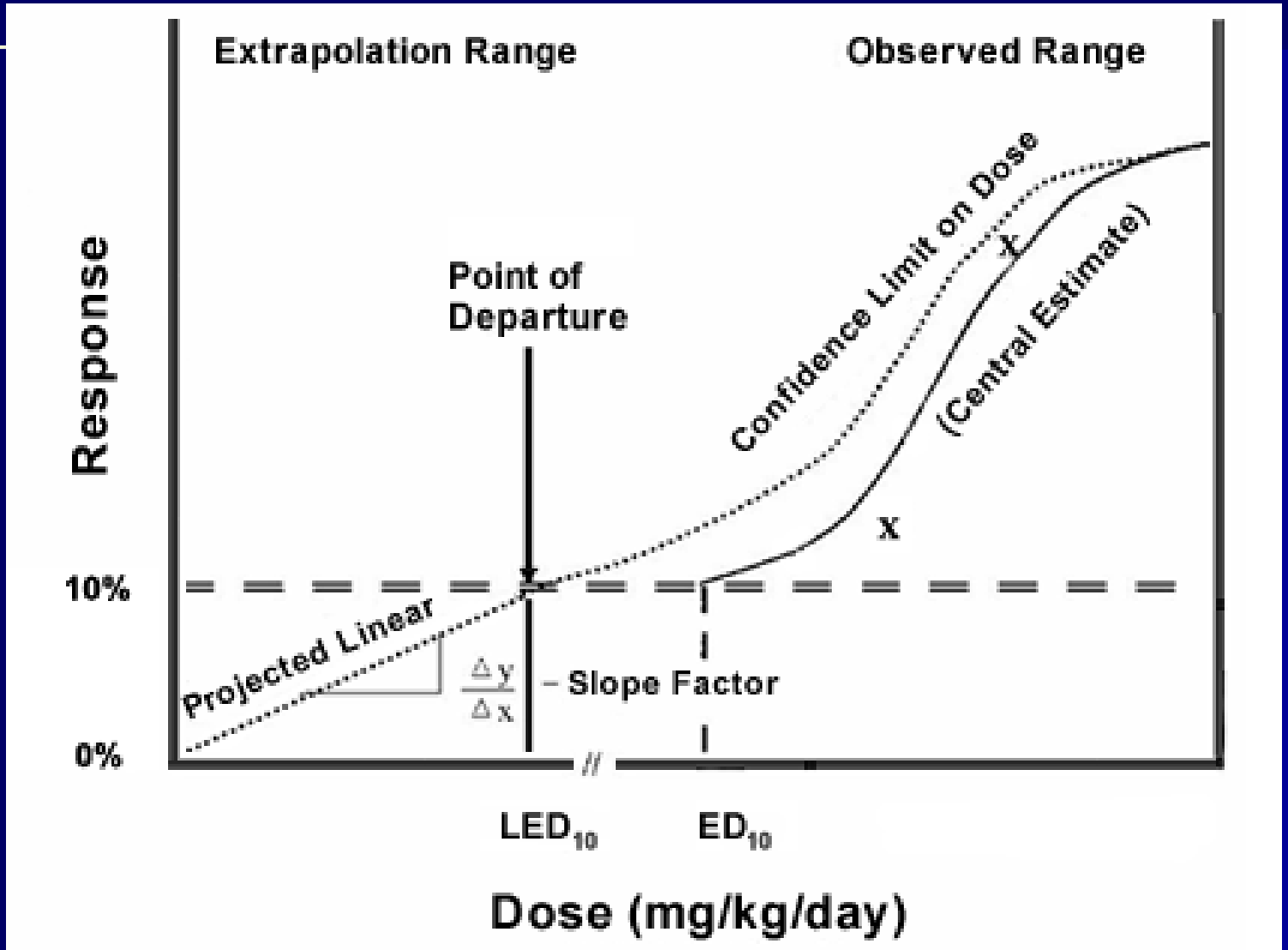
Reference Dose

Reference Dose

An estimate of an exposure that is likely to be without an appreciable risk of deleterious effects.

Derived from a NOAEL or LOAEL with uncertainty factors generally applied to reflect limitations of the data use.

Cancer


Extrapolation Range
Observed Range
Response
Point of Departure
Confidence Limit on Dose
(Central Estimate)
10%
0%
Projected Linear
Δy / Δx – Slope Factor
LED10
ED10
Dose (mg/kg/day)

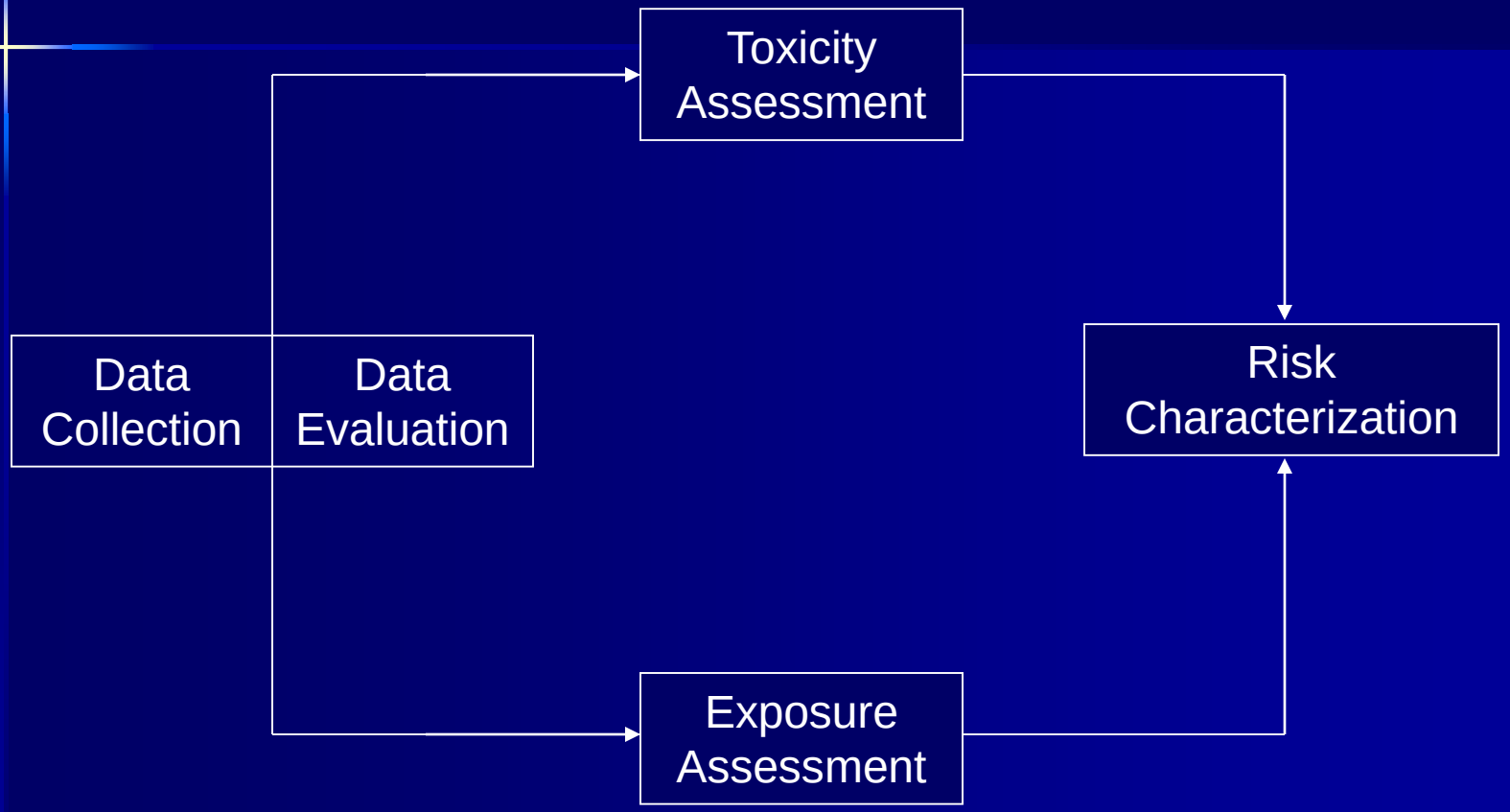
Cancer Slope Factor

- The upper 95 percent confidence limit on the probability of a response from a lifetime exposure to an agent.

Key: I = IRIS; P = PPRTV; A = ATSDR; C = Cal EPA; X = PPRTV Appendix; H = HEAST; J = New Jersey; E = Environmental Criteria and Assessment Office; S = see user guide Section 5; L = see user guide on lead; M = mutagen; V = volatile; F = See FAQ #29; c = cancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; n = noncancer; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide); SSL values are based on DAF=1

Toxicity and Chemical-specific information														Contaminant		Screening Levels												Protection of Ground Water SSLs	
SFO (mg/kg-day)$^{-1}$	key	IUR (ug/m^3)$^{-1}$	key	RfD_o (mg/kg-day)	key	RfC_i (mg/m^3)	key	volatile	muta-gen	GIABS	ABS	C_{sat} (mg/kg)	Analyte	CAS No.	Resident Soil (mg/kg)	key	Industrial Soil (mg/kg)	key	Resident Air (ug/m^3)	key	Industrial Air (ug/m^3)	key	Tapwater (ug/L)	key	MCL (ug/L)	Risk-based SSL (mg/kg)	MCL-based SSL (mg/kg)
1.8E-02	C	5.1E-06	C	1.5E-01	I					1	0.1		ALAR	1596-84-5	2.7E+01	c	9.6E+01	c	4.8E-01	c	2.4E+00	c	3.7E+00	c		8.2E-04	
8.7E-03	I			4.0E-03	I					1	0.1		Acephate	30560-19-1	5.6E+01	c**	2.0E+02	c*					7.7E+00	c*		1.7E-03	
		2.2E-06	I			9.0E-03	I	V		1		1.1E+05	Acetaldehyde	75-07-0	1.0E+01	c**	5.2E+01	c**	1.1E+00	c**	5.6E+00	c**	2.2E+00	c**		4.5E-04	
				2.0E-02	I					1	0.1		Acetochlor	34256-82-1	1.2E+03	n	1.2E+04	n					7.3E+02	n		5.8E-01	
				9.0E-01	I	3.1E+01	A	V		1		1.1E+05	Acetone	67-64-1	6.1E+04	n	6.3E+05	nms	3.2E+04	n	1.4E+05	n	2.2E+04	n		4.5E+00	
				3.0E-03	P	6.0E-02	P	V		1		1.1E+05	Acetone Cyanohydrin	75-86-5	2.0E+02	n	2.1E+03	n	6.3E+01	n	2.6E+02	n	5.8E+01	n		1.2E-02	
						6.0E-02	I	V		1		1.3E+05	Acetonitrile	75-05-8	8.7E+02	n	3.7E+03	n	6.3E+01	n	2.6E+02	n	1.3E+02	n		2.6E-02	
				1.0E-01	I			V		1		2.5E+03	Acetophenone	98-86-2	7.8E+03	ns	1.0E+05	nms					3.7E+03	n		1.1E+00	
3.8E+00	C	1.3E-03	C							1	0.1		Acetylaminofluorene, 2-	53-96-3	1.3E-01	c	4.5E-01	c	1.9E-03	c	9.4E-03	c	1.8E-02	c		8.2E-05	
				5.0E-04	I	2.0E-05	I	V		1		2.3E+04	Acrolein	107-02-8	1.5E-01	n	6.5E-01	n	2.1E-02	n	8.8E-02	n	4.2E-02	n		8.4E-06	
5.0E-01	I	1.0E-04	I	2.0E-03	I	6.0E-03	I		M	1	0.1		Acrylamide	79-06-1	2.3E-01	c	3.4E+00	c	9.6E-03	c	1.2E-01	c	4.3E-02	c		9.1E-06	
				5.0E-01	I	1.0E-03	I			1	0.1		Acrylic Acid	79-10-7	3.0E+04	n	2.9E+05	nm	1.0E+00	n	4.4E+00	n	1.8E+04	n		3.7E+00	
5.4E-01	I	6.8E-05	I	4.0E-02	A	2.0E-03	I	V		1		1.1E+04	Acrylonitrile	107-13-1	2.4E-01	c*	1.2E+00	c*	3.6E-02	c*	1.8E-01	c*	4.5E-02	c*		9.9E-06	
						6.0E-03	P			1	0.1		Adiponitrile	111-69-3	8.5E+06	nm	3.6E+07	nm	6.3E+00	n	2.6E+01	n					
5.6E-02	C			1.0E-02	I					1	0.1		Alachlor	15972-60-8	8.7E+00	c*	3.1E+01	c					1.2E+00	c	2.0E+00	9.9E-04	1.6E-03
				1.0E-03	I					1	0.1		Aldicarb	116-06-3	6.1E+01	n	6.2E+02	n					3.7E+01	n		9.1E-03	
				1.0E-03	I					1	0.1		Aldicarb Sulfone	1646-88-4	6.1E+01	n	6.2E+02	n					3.7E+01	n		8.0E-03	
1.7E+01	I	4.9E-03	I	3.0E-05	I					1	0.1		Aldrin	309-00-2	2.9E-02	c*	1.0E-01	c	5.0E-04	c	2.5E-03	c	4.0E-03	c		6.5E-04	
				2.5E-01	I					1	0.1		Allyl	74223-64-6	1.5E+04	n	1.5E+05	nm					9.1E+03	n		3.5E+00	
				5.0E-03	I	1.0E-04	X			1	0.1		Allyl Alcohol	107-18-6	3.0E+02	n	3.1E+03	n	1.0E-01	n	4.4E-01	n	1.8E+02	n		3.7E-02	
2.1E-02	C	6.0E-06	C			1.0E-03	I	V		1		1.4E+03	Allyl Chloride	107-05-1	6.8E-01	c**	3.4E+00	c**	4.1E-01	c**	2.0E+00	c**	6.5E-01	c**		2.1E-04	
				1.0E+00	P	5.0E-03	P			1			Aluminum	7429-90-5	7.7E+04	n	9.9E+05	nm	5.2E+00	n	2.2E+01	n	3.7E+04	n		5.5E+04	
				4.0E-04	I					1			Aluminum Phosphide	20859-73-8	3.1E+01	n	4.1E+02	n					1.5E+01	n			
				3.0E-04	I					1	0.1		Amdro	67485-29-4	1.8E+01	n	1.8E+02	n					1.1E+01	n		3.9E+03	
				9.0E-03	I					1	0.1		Ametryn	834-12-8	5.5E+02	n	5.5E+03	n					3.3E+02	n		3.5E-01	
2.1E+01	C	6.0E-03	C							1	0.1		Aminobiphenyl, 4-	92-67-1	2.3E-02	c	8.2E-02	c	4.1E-04	c	2.0E-03	c	3.2E-03	c		1.6E-05	
				8.0E-02	P					1	0.1		Aminophenol, m-	591-27-5	4.9E+03	n	4.9E+04	n					2.9E+03	n		1.1E+00	
				2.0E-02	P					1	0.1		Aminophenol, p-	123-30-8	1.2E+03	n	1.2E+04	n					7.3E+02	n		2.8E-01	
				2.5E-03	I					1	0.1		Amitraz	33089-61-1	1.5E+02	n	1.5E+03	n					9.1E+01	n		4.7E+01	
						1.0E-01	I			1			Ammonia	7664-41-7					1.0E+02	n	4.4E+02	n					
				7.0E-04	I					1			Ammonium Perchlorate	7790-98-9	5.5E+01	n	7.2E+02	n					2.6E+01	n			
				2.0E-01	I					1			Ammonium Sulfamate	7773-06-0	1.6E+04	n	2.0E+05	nm					7.3E+03	n			
5.7E-03	I	1.6E-06	C	7.0E-03	P	1.0E-03	I			1	0.1		Aniline	62-53-3	8.5E+01	c**	3.0E+02	c*	1.0E+00	n	4.4E+00	n	1.2E+01	c*		4.0E-03	
				4.0E-04	I					0.15			Antimony (metallic)	7440-36-0	3.1E+01	n	4.1E+02	n					1.5E+01	n	6.0E+00	6.6E-01	2.7E-01
				5.0E-04	H					0.15			Antimony Pentoxide	1314-60-9	3.9E+01	n	5.1E+02	n					1.8E+01	n			
				9.0E-04	H					0.15			Antimony Potassium Tartrate	11071-15-1	7.0E+01	n	9.2E+02	n					3.3E+01	n			
				4.0E-04	H					0.15			Antimony Tetroxide	1332-81-6	3.1E+01	n	4.1E+02	n					1.5E+01	n			
						2.0E-04	I			0.15			Antimony Trioxide	1309-64-4	2.8E+05	nm	1.2E+06	nm	2.1E-01	n	8.8E-01	n					
				1.3E-02	I					1	0.1		Apollo	74115-24-5	7.9E+02	n	8.0E+03	n					4.7E+02	n		2.9E+01	
2.5E-02	I	7.1E-06	I	5.0E-02	H					1	0.1		Aramite	140-57-8	1.9E+01	c	6.9E+01	c	3.4E-01	c	1.7E+00	c	2.7E+00	c		3.0E-02	
1.5E+00	I	4.3E-03	I	3.0E-04	I	1.5E-05	C			1	0.03		Arsenic, Inorganic	7440-38-2	3.9E-01	c*	1.6E+00	c	5.7E-04	c*	2.9E-03	c*	4.5E-02	c	1.0E+01	1.3E-03	2.9E-01
				3.5E-06	C	5.0E-05	I			1			Arsine	7784-42-1	2.7E-01	n	3.6E+00	n	5.2E-02	n	2.2E-01	n	1.3E-01	n			
				9.0E-03	I					1	0.1		Assure	76578-14-8	5.5E+02	n	5.5E+03	n					3.3E+02	n		5.1E+00	
				5.0E-02	I					1	0.1		Asulam	3337-71-1	3.1E+03	n	3.1E+04	n					1.8E+03	n		4.7E-01	
2.3E-01	C			3.5E-02	I					1	0.1		Atrazine	1912-24-9	2.1E+00	c	7.5E+00	c					2.9E-01	c	3.0E+00	1.9E-04	1.9E-03
8.8E-01	C	2.5E-04	C							1	0.1		Auramine	492-80-8	5.5E-01	c	2.0E+00	c	9.7E-03	c	4.9E-02	c	7.6E-02	c		7.0E-04	
				4.0E-04	I					1	0.1		Avermectin B1	65195-55-3	2.4E+01	n	2.5E+02	n					1.5E+01	n		2.6E+01	
1.1E-01	I	3.1E-05	I					V		1			Azobenzene	103-33-3	5.1E+00	c	2.3E+01	c	7.8E-02	c	4.0E-01	c	1.2E-01	c		9.6E-04	
				2.0E-01	I	5.0E-04	H			0.07			Barium	7440-39-3	1.5E+04	n	1.9E+05	nm	5.2E-01	n	2.2E+00	n	7.3E+03	n	2.0E+03	3.0E+02	8.2E+01
				4.0E-03	I					1	0.1		Baygon	114-26-1	2.4E+02	n	2.5E+03	n					1.5E+02	n		4.7E-02	
				3.0E-02	I					1	0.1		Bayleton	43121-43-3	1.8E+03	n	1.8E+04	n					1.1E+03	n		8.7E-01	
				2.5E-02	I					1	0.1		Baythroid	68359-37-5	1.5E+03	n	1.5E+04	n					9.1E+02	n		2.4E+02	
				3.0E-01	I					1	0.1		Benefin	1861-40-1	1.8E+04	n	1.8E+05	nm					1.1E+04	n		3.6E+02	
				5.0E-02	I					1	0.1		Benomyl	17804-35-2	3.1E+03	n	3.1E+04	n					1.8E+03	n		1.6E+00	
				3.0E-02	I					1	0.1		Bentazon	25057-89-0	1.8E+03	n	1.8E+04	n					1.1E+03	n		2.4E-01	
				1.0E-01	I			V		1		1.2E+03	Benzaldehyde	100-52-7	7.8E+03	ns	1.0E+05	nms					3.7E+03	n		8.1E-01	
5.5E-02	I	7.8E-06	I	4.0E-03	I	3.0E-02	I	V		1		1.8E+03	Benzene	71-43-2	1.1E+00	c*	5.4E+00	c*	3.1E-01	c	1.6E+00	c*	4.1E-01	c	5.0E+00	2.1E-04	2.6E-03
				1.0E-05	H			V		1		1.3E+03	Benzenethiol	108-98-5	7.8E-01	n	1.0E+01	n					3.7E-01	n		2.4E-04	
2.3E+02	I	6.7E-02	I	3.0E-03	I				M	1	0.1		Benzidine	92-87-5	5.0E-04	c	7.5E-03	c	1.4E-05	c	1.8E-04	c	9.4E-05	c		2.4E-07	
				4.0E+00	I					1	0.1		Benzoic Acid	65-85-0	2.4E+05	nm	2.5E+06	nm					1.5E+05	n		3.4E+01	
1.3E+01	I							V		1		3.2E+02	Benzotrichloride	98-07-7	4.9E-02	c	2.2E-01	c					5.2E-03	c		1.1E-05	
				1.0E-01	P					1	0.1		Benzyl Alcohol	100-51-6	6.1E+03	n	6.2E+04	n					3.7E+03	n		8.9E-01	
1.7E-01	I	4.9E-05	C	2.0E-03	P	1.0E-03	P	V		1		1.5E+03	Benzyl Chloride	100-44-7	1.0E+00	c*	4.9E+00	c*	5.0E-02	c*	2.5E-01	c*	7.9E-02	c*		8.7E-05	
		2.4E-03	I	2.0E-03	I	2.0E-05	I			0.007			Beryllium and compounds	7440-41-7	1.6E+02	n	2.0E+03	n	1.0E-03	c*	5.1E-03	c*	7.3E+01	n	4.0E+00	5.8E+01	3.2E+00
				1.0E-04	I					1	0.1		Bidrin	141-66-2	6.1E+00	n	6.2E+01	n					3.7E+00	n		8.5E-04	

Risk Assessment Paradigm



Exposure Assessment

- The estimation of actual and/or potential exposures, their duration and frequency, and the pathways of exposure.

The Exposure Assessment Process

STEP 1

Characterize Exposure Setting

- Physical Environment
- Potential exposed populations

STEP 2

Identify Exposure Pathways

- Chemical source / release
- Exposure point
- Exposure route

STEP 3

Quantify Exposure

Source: US EPA 1989c

Characterize Exposure Setting

- Physical Environment
  - Climate
  - Vegetation
  - Soil Type
  - Surface Water
  - Ground Hydrology

Characterize Exposure Setting

- Potentially Exposed Populations
  - Location Relative to the Site
    - Individuals on or near site
    - Distant populations
    - Individuals with potential for future exposure
  - Current and Future Land Use
    - Residential
    - Commercial/Industrial
    - Recreational
    - Agricutural

Characterize Exposure Setting

- Potentially Exposed Populations
  - Activity Patterns
    - Site use – if unrestricted
    - Site-specific population characteristics
    - Percent of time spent on site
    - Seasonal Activity variations
    - Indoor/Outdoor activities

Quantify Exposure

- Reasonable Maximum Exposure (RME)
  - The highest exposure that is reasonably expected to occur at a site.
- Central Tendency Estimate (CTE)
  - The average or typical individual in the population.

Calculating Intake

Water (mg/L)

Soil (mg/kg)

Air (mg/m^3)

Food (mg/kg)

X

Exposure Factors → Intake

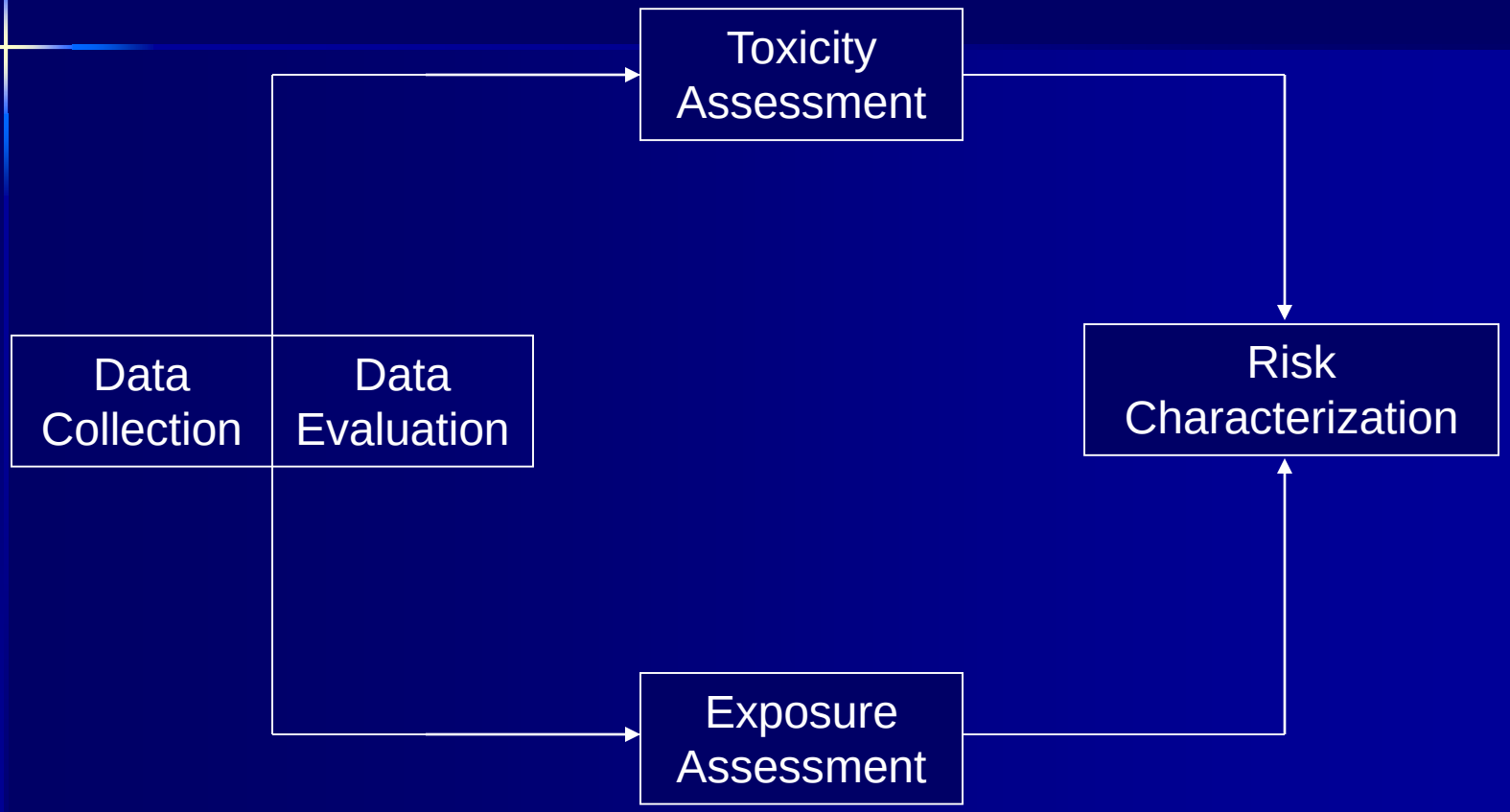
Exposure Times

- Residential
  - 24 hours a day for 350 days per year for 26 years
- Commercial/Industrial
  - 8 hours a day for 250 days a year for 25 years

Assumptions

- All concerned parties must agree to the assumptions prior to the risk assessment being performed.

Risk Assessment Paradigm



Risk Characterization

Putting it all together to determine the potential for adverse effects to occur from exposure to a contaminant and the evaluation of the uncertainty involved.

Summarize the Risk Assessment

- Provide concise summary of risk characterization results
- Discuss uncertainties
- Highlight potential sources of risk to be addressed by risk managers.

Quantify Cancer Risks

EPA uses the target risk range of 1 in 10,000 to 1 in 1,000,000 ($1x10^{-4}$ to $1x10^{-6}$) to manage risks as a part of a Superfund cleanup

1 in 100

1 in 1,000

1 in 10,000

1 in 100,000

1 in 1,000,000

Quantify Non-Cancer Risks

A Hazard Quotient is the daily intake divided by the reference dose for each chemical.

A Hazard Index is the sum of the Hazard Quotients for each chemical

US EPA recommends a HQ of <1

- >3
- 1
- <1

And that…

- Is the crash course to understanding the process of performing a Superfund Risk Assessment!!!

ANY QUESTIONS??